Low Multiplicity - 1

Abstract: Survey of located events with three or less charged tracks. Comparison of characteristics between higher multiplicity events is shown to check for systematic problems.

Purpose

The Phase 2 data now includes vertices with only one recognized track and a greater proportion of two-track vertices as well. The location of low-multiplicity events is often not unique and may be systematically biased with respect to the high-multiplicity events, which are nearly free of background.

1 - Expected Multiplicity Distribution

The multiplicity distribution from the data is shown in Fig. 1 together with the expected distribution subject to cuts in accepted angle and momentum of the charged emulsion tracks. The Monte Carlo data shown are the charged tracks from LEPTO with explicit transverse angle and momentum cuts. The LEPTO multiplicity compares favorably to the data. The difference in the comparison to the data between the various cuts is not statistically significant (as long as $\theta_{\mu\alpha\xi} > 350$ mrad). The following table summarizes the Monte Carlo study for accepted multiplicity versus low-momentum cutoff and maximum angle cutoff. The cuts in the data made during the analysis are not step function cuts, of course, but are gradual. More study is needed to determine the actual shape of the acceptance. The mean multiplicity

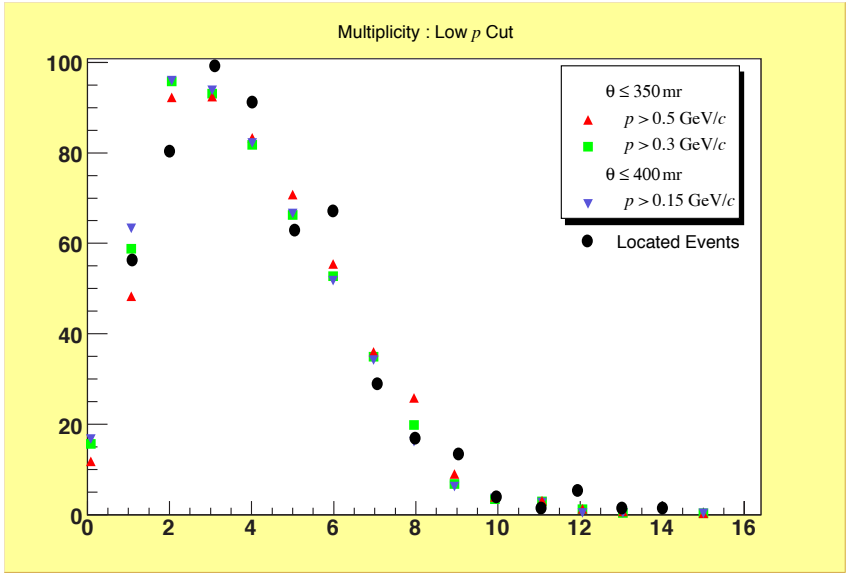


Figure 1. Multiplicity distributions. (*top*) Data from 534 located events and Monte Carlo with different cuts in maximum angle. (*bottom*) and cuts in minimum momentum.

in the located sample is 4.16, as compared to the Monte Carlo, which ranges from 3.42 for overly pessimistic cuts to 4.15 for the loosest cuts.

Max θ	*p*>0.15	*p*>0.30	*p*>0.5	*p*>0.8
0.25				3.42
0.30				3.58
0.35		4.01	3.89	3.71
0.4	4.15			

Table 1. Monte Carlo charged multiplicity. A "sparse" table of multiplicity from LEPTO with several cuts applied to maximum accepted angle and minimum accepted momentum. Angles in radians and momentum in GeV/*c*.

Assuming the best matching case of p>0.15 GeV/c and $\theta_{\mu\alpha\xi}$= 0.4 radians, the Monte Carlo predicts that 12% of the visible interactions (multiplicity of accepted charged tracks > 0) are multiplicity one. Not visible interactions are estimated to be 3% of the total. This case matches to the data with a statistical chi-square of χ^2=10.85/10 d.o.f.

In particular, for the multiplicity, *m*, equal to one, the Monte Carlo predicts from 48 to 63 events depending on the energy cut. Since the data has 53 events with *m*=1, the discrimination is weak. Or, equivalently, the systematic errors introduced with varying or unknown energy cuts in the data are significant only to the 1-σ level.

2 - Distribution by Station

Figure 2 shows how the events are distributed by station number. A non-biased, *m*=1 distribution should follow the located distribution. The *m*=1 is within one standard deviation (statistical error) for all stations. There is no apparent bias.

3 - Distribution within Station

To check if the *z* distribution of *m*=1 vertices are selected with the same criteria as the rest of the located vertices, the value of z_{vtx} - z_0 is plotted, with z_0 the position of the downstream end of the module. Figure 3 (*top*) shows the comparison. The bottom part of Figure 3 shows the comparison between located and not located vertices. An enhancement around z_{vtx} - z_0 = 0 is noted for both comparisons.

4 - Distribution in *x-y* Plane

The transverse distribution of *m*=1 vertices can be also be

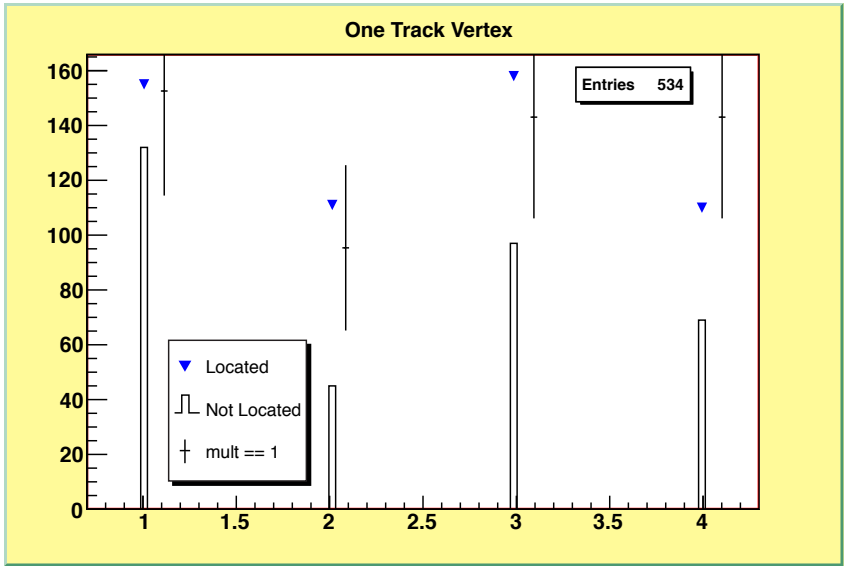
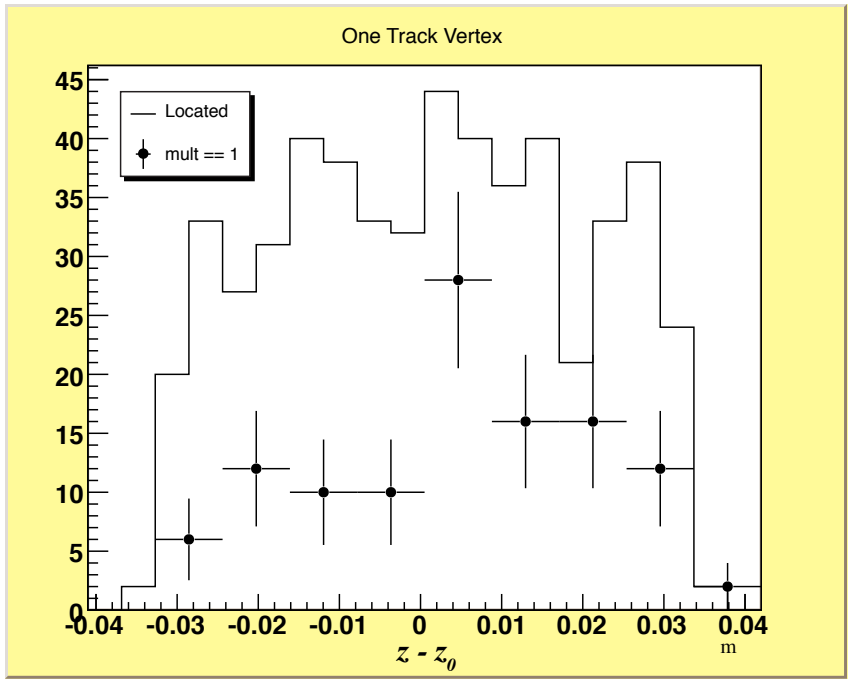


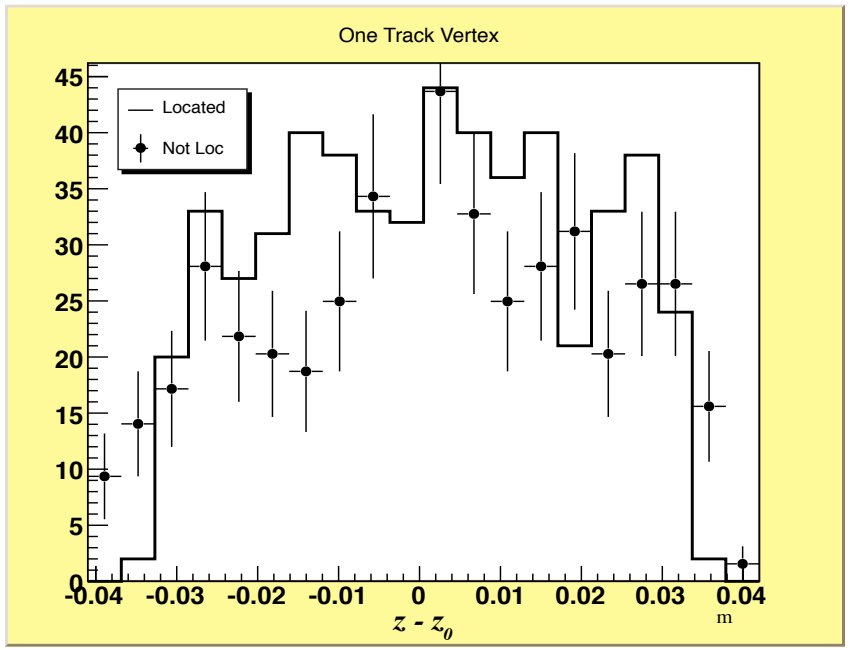
Figure 2. Distribution by station.
Shown are the located (*triangles*), not located (histogram) and *m*=1 events. One track vertices are normalized to the number of located events, with the error bars in correct proportion.

checked against the distribution for all vertices, since they should be indistinguishable. Figure 4 shows a scatter plot of three data sets: all interaction candidates (830 events), located events (534 events), and the *m*=1 events (53 events). There is a clear background contamination all candidates compared to the located set, but no obvious problem with the single-track set. Figures 5 and 6 show each component. The *y* distribution shows more fluctuations than would be expected from statistics.

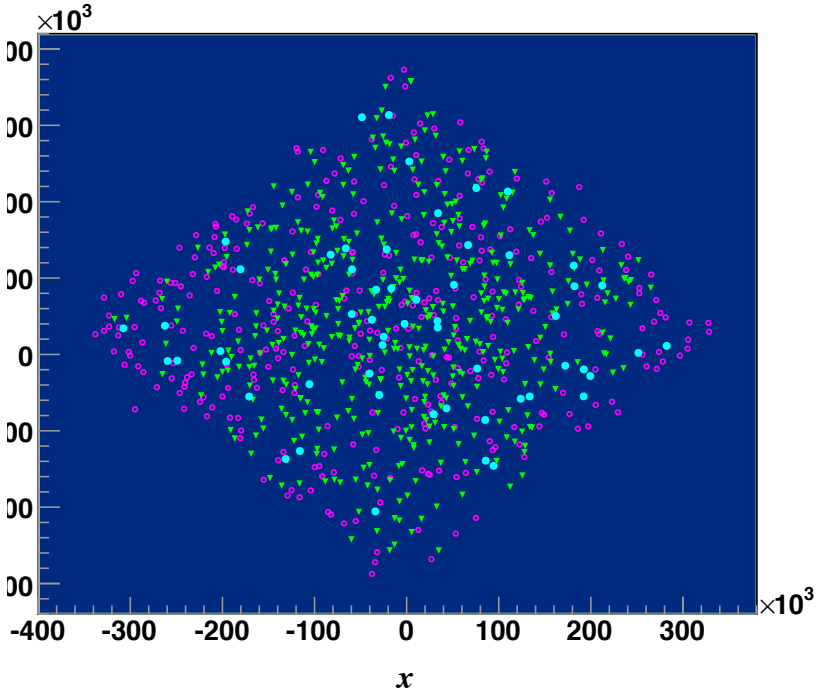
5 - Muon Fraction and Momentum

There are 28 events in the *m*=1 set that are muons, which is 53±10% of the total. The number of positive muons is equal to the number of negative muons (14), so the negative to positive





(*Left*) Figure 3. *z* distribution within station. The *z* location of vertices relative to the downstream end of each module are combined in each plot. The *m*=1 vertices are compared to all located events (*top*) and located events are compared to not located events (*bottom*).



(*Top*) Figure 4. *x-y* Distribution of events. Shown are all located events (*green triangles*), not located events (*small purple dots*), and *m*=1 located events (*large blue dots*). The not located events clearly do not have the same distribution as located events.

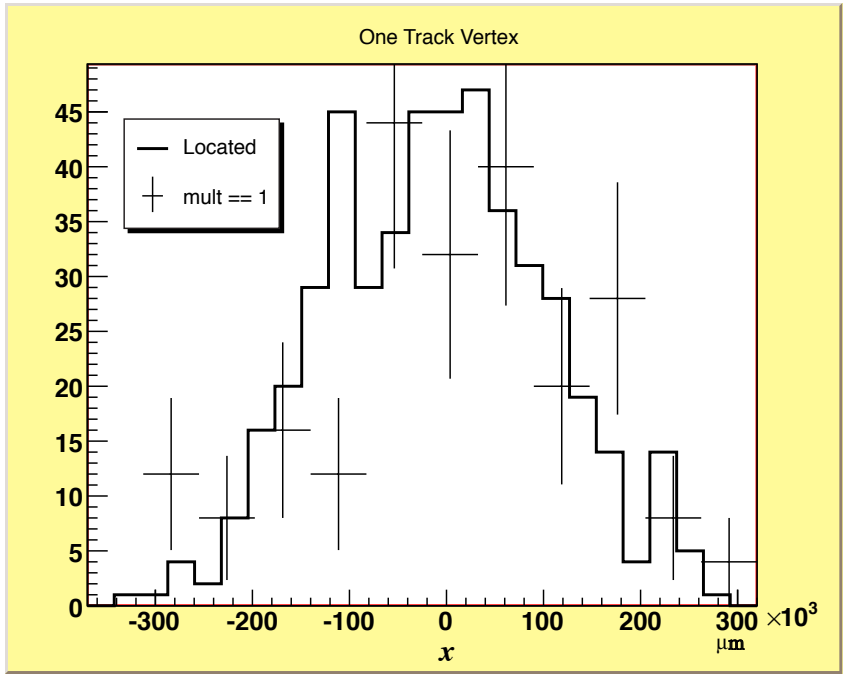


Figure 5. *x*-distribution for one-track vertices.
The χ^2 of matching is 12.3 for 11 dof.

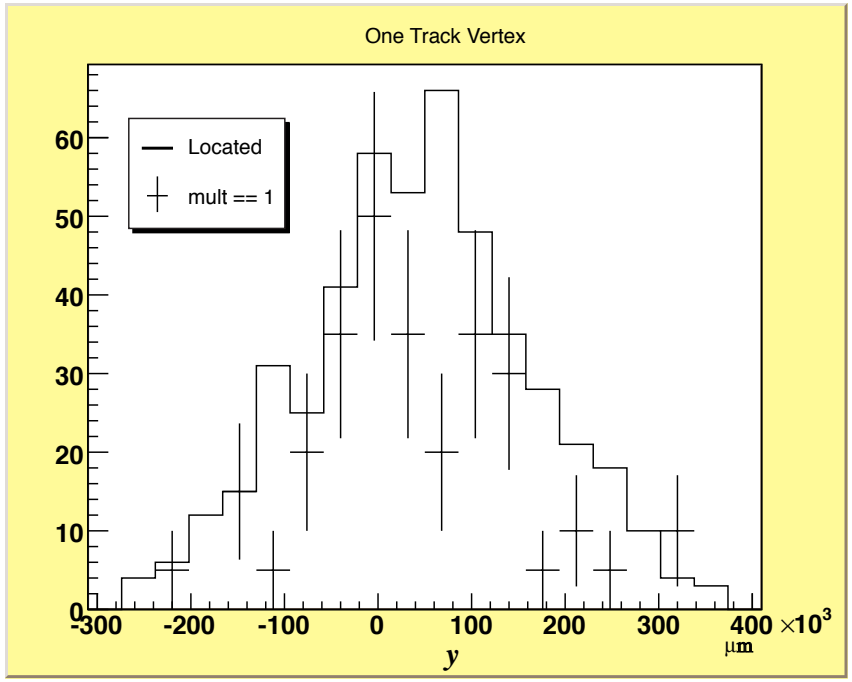


Figure 6. *y*-distribution for one-track vertices.
The χ^2 of matching is 37.8 for 14 dof.

ratio is 1.0±0.4. The fraction of muon charged-current events in the located set is 43±7%. The ratio of negative to positive muons is 1.49±0.20 (136/91). This is compatible for these low numbers.

The average muon momentum for the m=1 events is 27 GeV/c compared with 32.1 GeV/c for the located muons. The distribution is shown in Fig. 9.

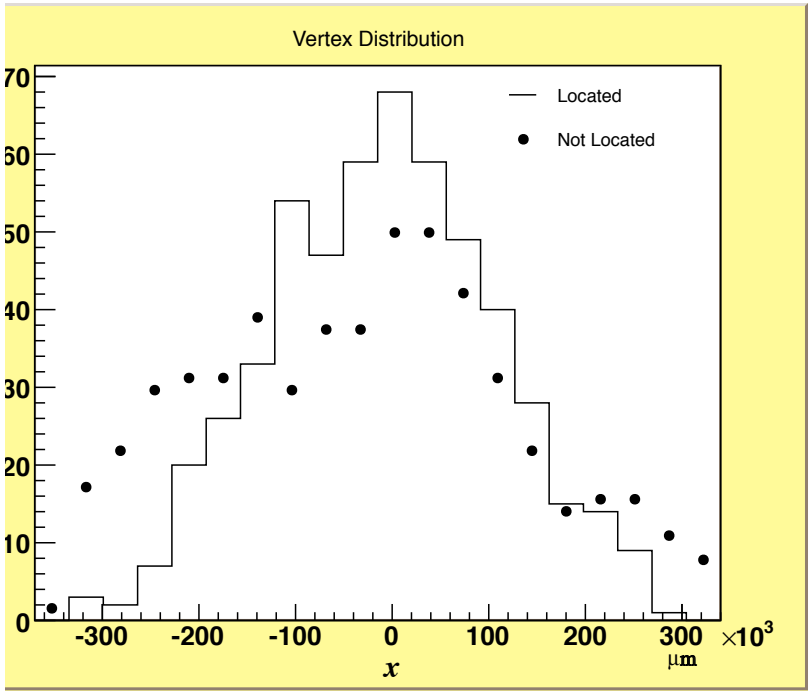


Figure 7. *x*-distribution for located and not located vertices.
The not located set has a clear relative excess at large |x|. This may be from events along the edge of the emulsion frames.

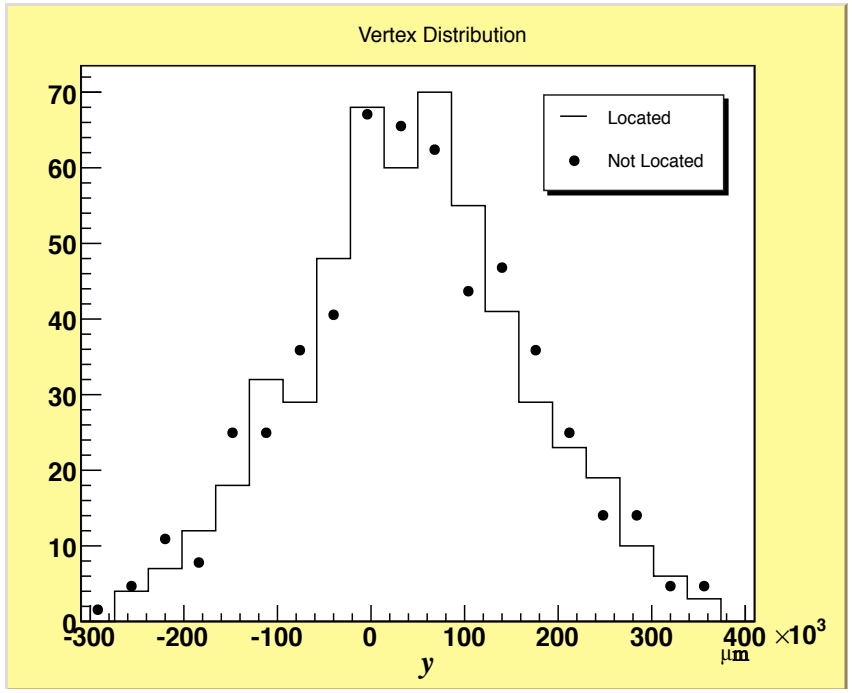


Figure 8. *y*-distribution of located and not located vertices.
There is no significant difference is this view.

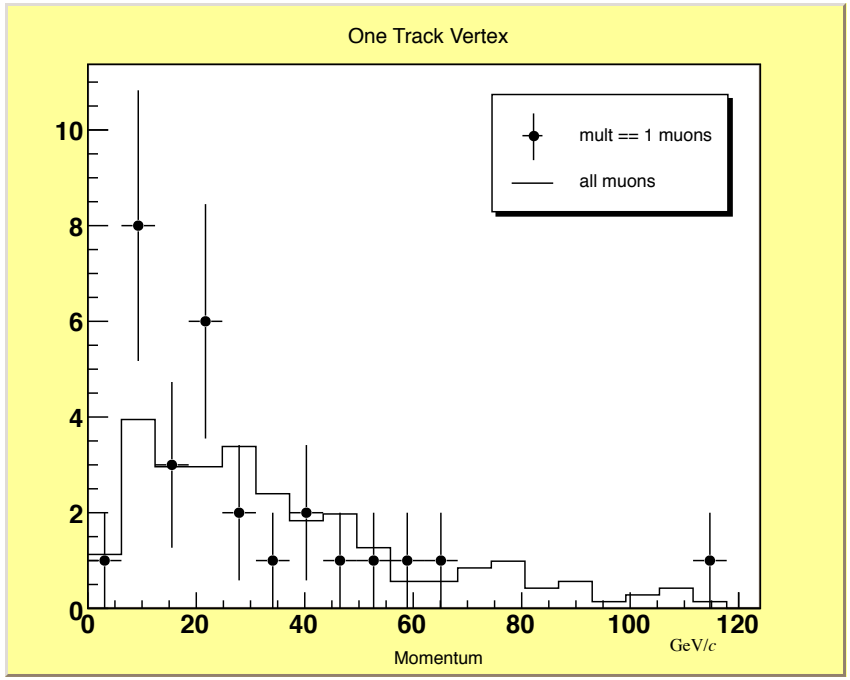


Figure 8. Muon momentum comparison.